Critical Operating Constraints & Probabilistic Congestion Forecasting

How to Prevent Short-Term and Long-Term Blackouts in California while Meeting Renewable Portfolio Standards?

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

Outline

- Acknowledgement
- Why these two research topics?
- What were achieved?
- What this means for the future of California?

Acknowledgement for Two Projects

- Sponsored by
  PIER Transmission Research Program 2006-2007
- TRP Project Managers: Jim Cole, Larry Miller, Virgil Rose
- Research Organization: EPRI
  - Steve Lee, Principal Investigator
  - Liang Min
  - Guorui Zhang
  - Peter Hirsch
- CAISO Champions:
  - Jim Detmers, VP of Operations
  - Armando Perez, retired VP of Planning
- EPRI Cost Sharing – prior research and workshop

Jim Detmers foresaw the need of this tool in 2005 and EPRI had done prior research that would enable this method to be tested.

Why Critical Operating Constraints Forecasting (COCF)?

- Technology Challenge
  - Not enough power plants in Southern California and not enough transmission capacities to bring power in
  - Existing control center tools do not predict critical operating constraints
  - Jim Detmers:

"Grid operators need a tool to predict when and where they will need to take emergency actions to overcome a transmission bottleneck. A 2-hour warning means preventing a blackout. We need this capability to prevent and solve power crisis during summer months"

Disclaimer: The photo and the quotation are unrelated.

- Solution
  - Develop forecasts of critical operating constraints for the next 24 hours
  - Simulate different power purchase scenarios
  - If unavoidable, plan for load reduction in advance

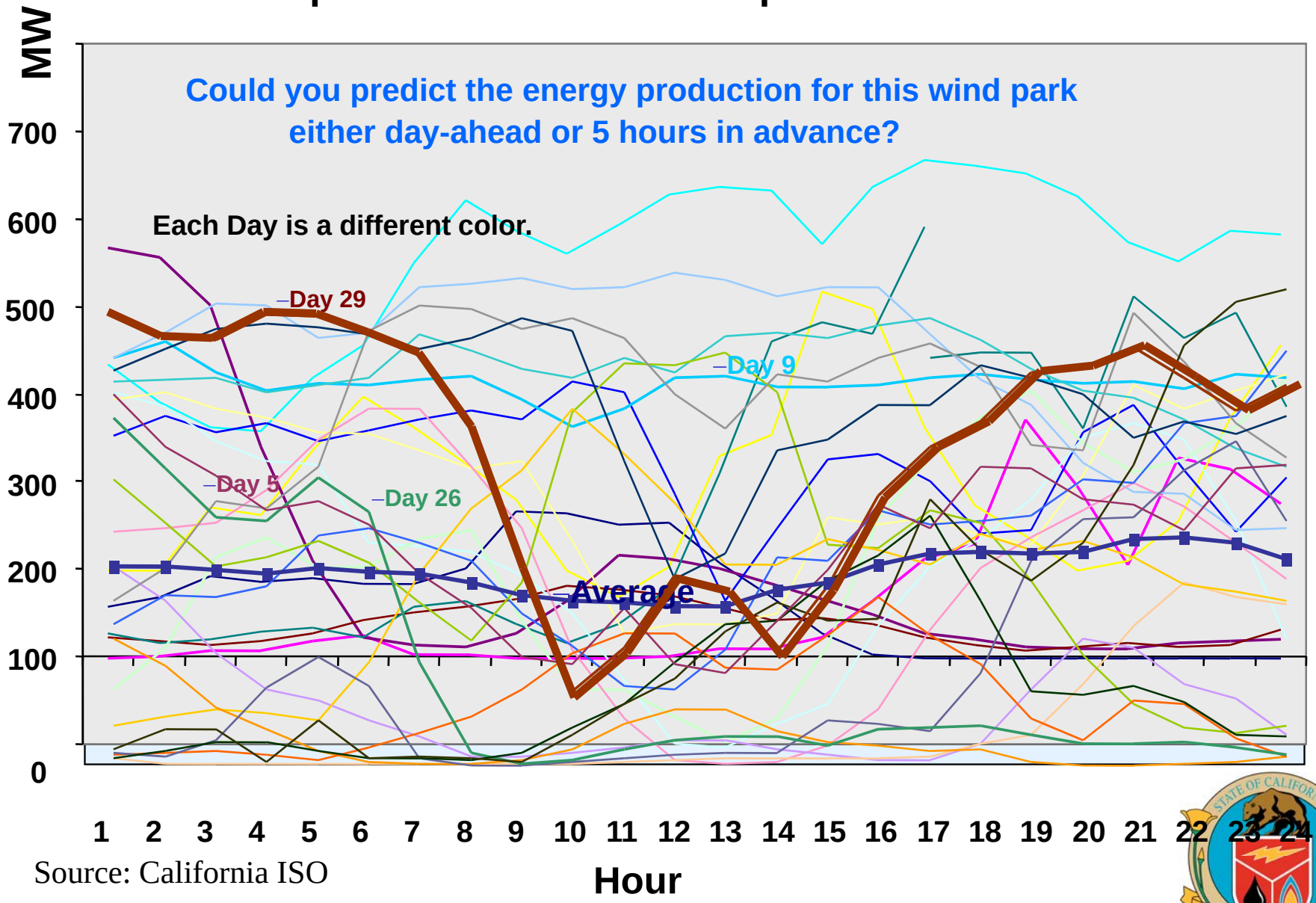
Why Probabilistic Congestion Forecasting (PCF)?

- Research Challenge
  - Uncertainties of short term and long term transmission congestion
  - Difficulties in siting and building more transmission lines
  - Effects of renewable generation and demand options on transmission congestion
- Solution
  - Develop short term and long term probabilistic forecasts of transmission congestion
  - Use the tools to evaluate different scenarios
- Future Work
  - **Studies to assess policy implications to manage transmission congestion**
  - **Wind Integration and Holistic Planning**

What Uncertainties?

- Hydro power (drought, normal or wet)
- Weather effect on customer demand
- Equipment failures - generators or transmission on outage
- Power market and fuel price fluctuations
- Location and type of future power plants
- Increasing amounts of **Wind** and solar power present additional HUGE uncertainties for grid integration
- Future **Electric Vehicles** – charging load and emergency generation present both risk and opportunities for grid operation

Tehachapi Wind Generation in April – 2005



Source: California ISO

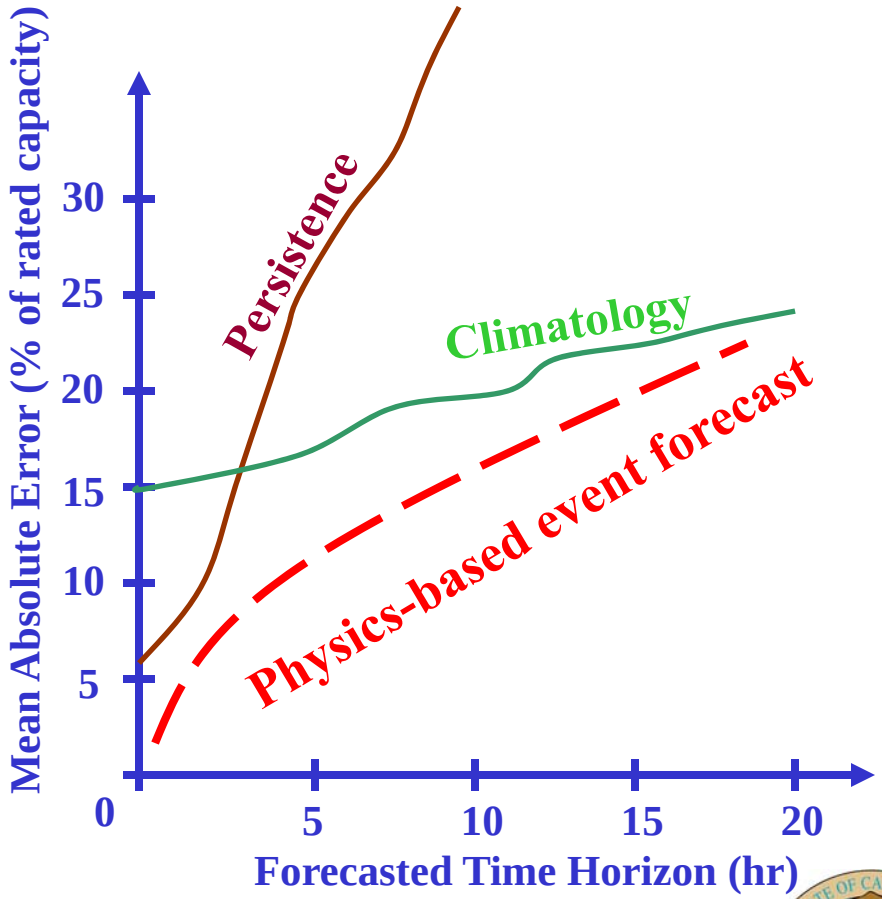
Questions for Audience

- After seeing this graph, would you say
- It is harder to forecast wind output in the short term?
- Or it is harder to forecast wind output in the long term?

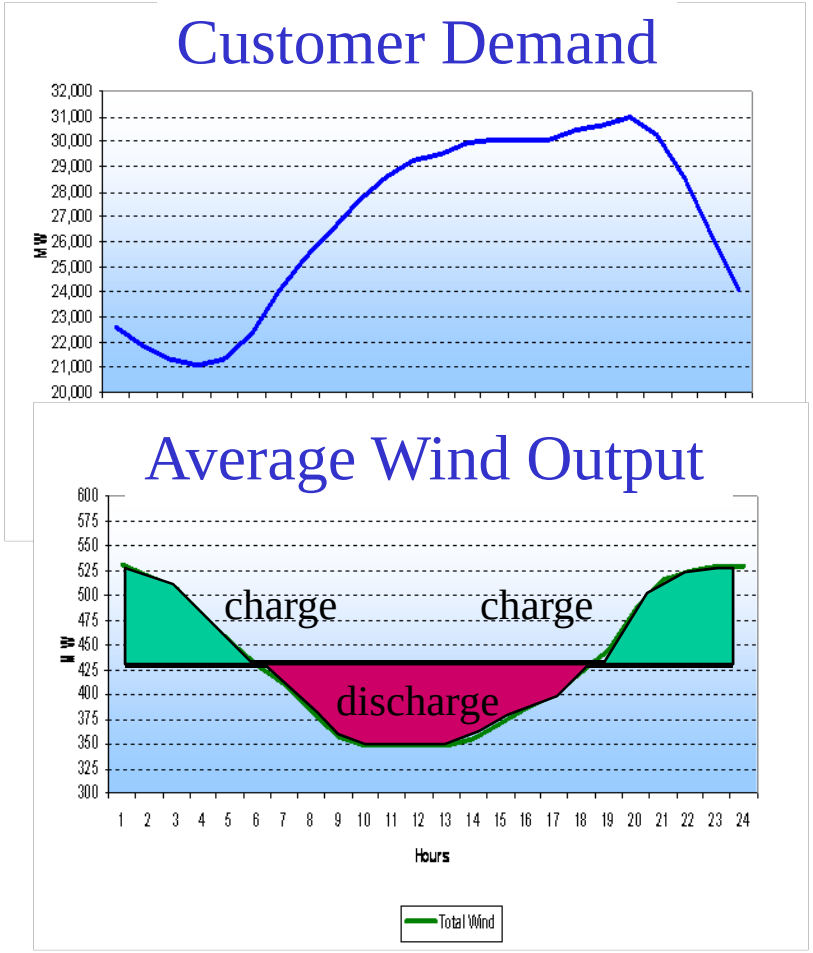
Answers:
Short-term wind forecast can be more accurate if more real-time weather data is available.
Long-term wind forecast accuracy is much harder to improve.

Short-Term Wind Uncertainty

- Confidence about wind forecast gets better when the forecast window is shorter
- Assuming “Persistence” of current wind output is more accurate than using climatology for up to about 5 hrs
- Physics-based Event Forecast of up or down ramps of wind output is critical for grid operation



Long-Term Wind Uncertainty

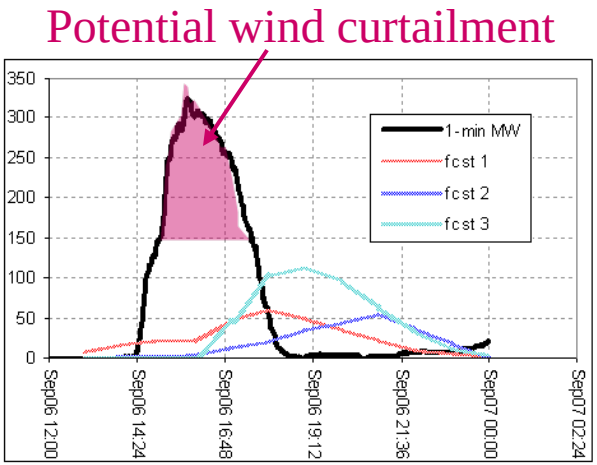


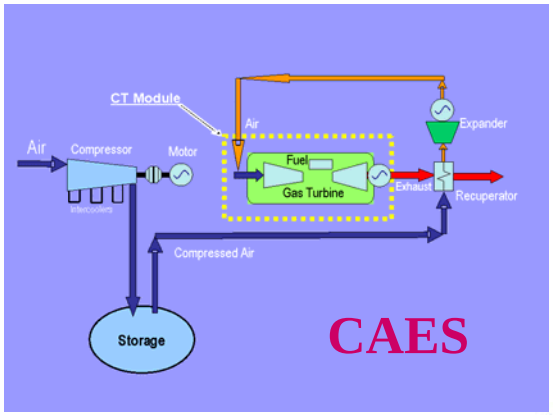
Source: California ISO

- Even if we ignore the high variability of wind output, average wind output is low when customer demand is high
- We need storage to re-time the wind power
- We also need demand response or demand control to re-time the demand

Methods of Coping with Wind Uncertainty

- Short-Term
  - Better wind forecasting
  - Carry more operating and spinning reserve to handle up and down ramps of wind output
  - Rapid coordination with demand response and energy storage
- Long-Term
  - Build more energy storage, e.g., Compressed Air Energy Storage (CAES)
  - Controllable demand response
  - Holistic planning of transmission, generation and demand

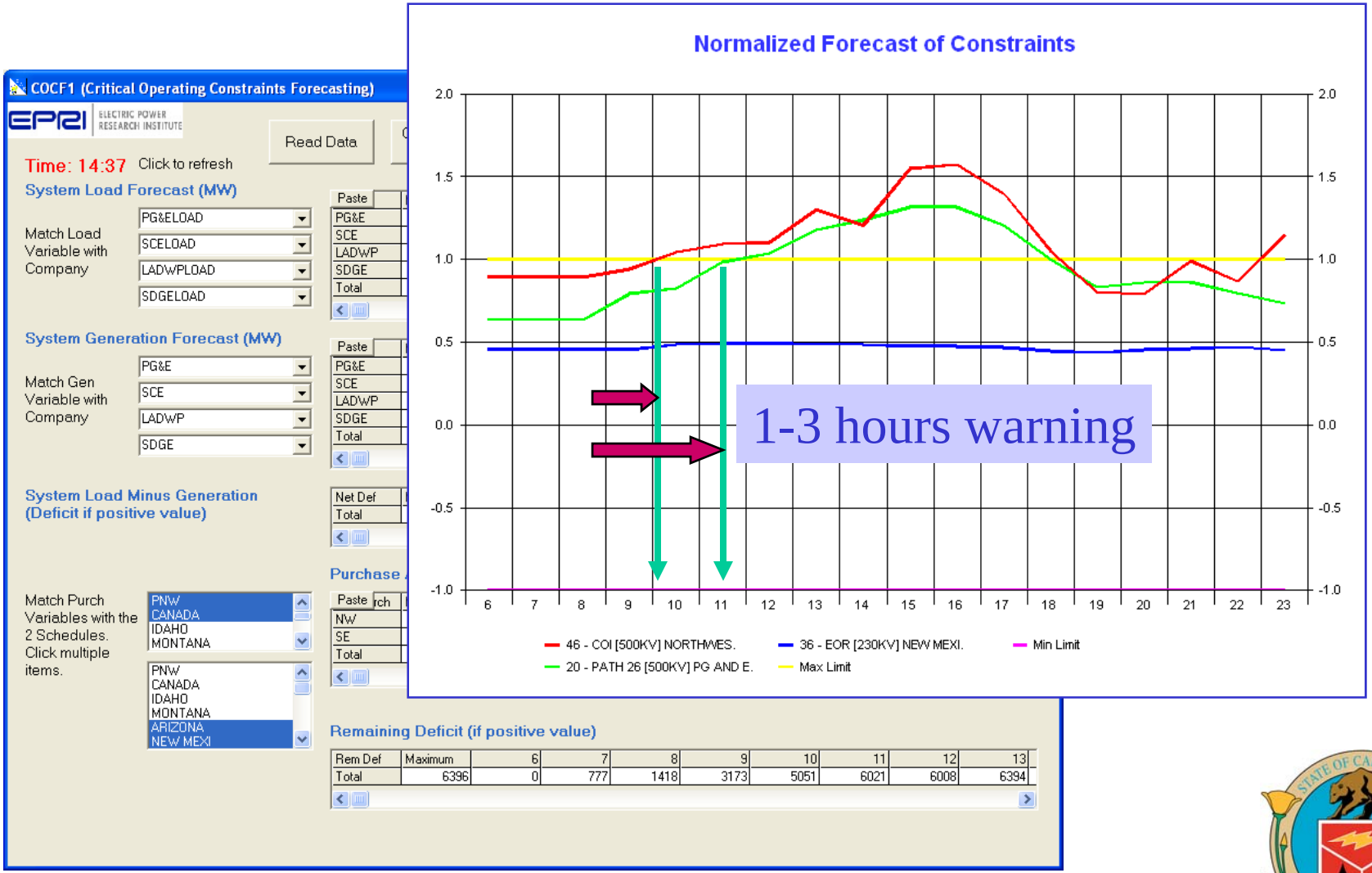




What Were Achieved?

- Demonstration of the COCF prototype in the CAISO control center (5/2006)
- Developed and tested PCF for short term and long term congestion forecasting
- Workshop to present Functional Specs of COCF and results of PCF (11/2007)
- Final reports
- IEEE Paper

COCF Prototype

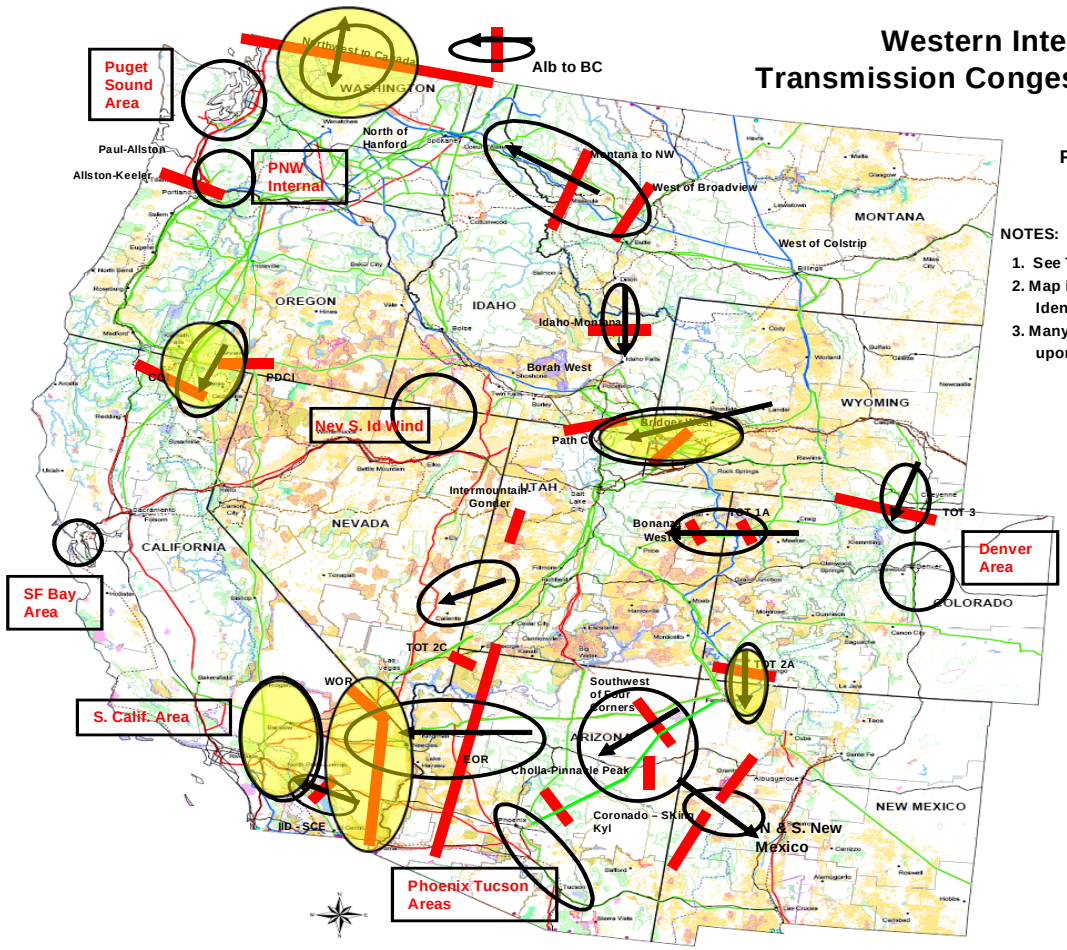


COCF Validation on May 31, 2006

- Data preparation – May 30, 2006 (2 pm to 5 pm)
  - CAISO: Jim McIntosh, Jamal Batakji, Tamara Elliott, Dave Hawkins
  - EPRI: Steve Lee, Peter Hirsch, Guorui Zhang
  - Day-ahead load and resource forecasts
  - Identified major line outage = Round Mountain – Table Mountain #2 (500KV) resulting in COI limit derated to 2750 MW from 4800 MW
  - Request study assumptions on Summer 2006 Assessment for 1 in 10 Forecast
  - Familiarize with major paths to be monitored and forecasted
- May 31, 2006
  - 8:00 am to 2 p.m., Put COCF to the test
  - 2:00 pm, 1 Hour Review and Demonstration (Jim Detmers, Jim McIntosh, Patrick Truong, Dave Hawkins)

Conclusion: COCF was capable of prediction for both the short term and also for the 1 in 10 Forecast case

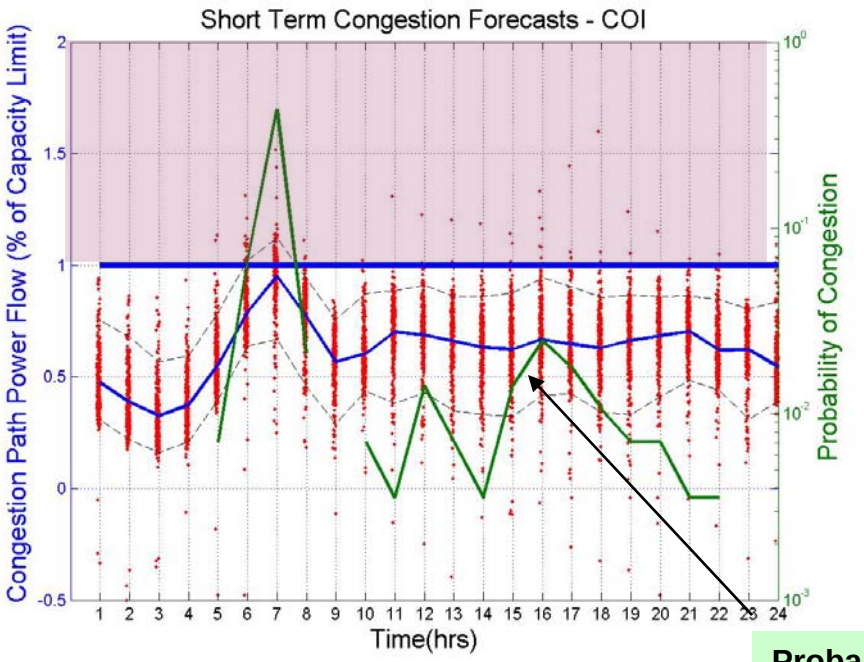
Congested Paths Forecasted by PCF



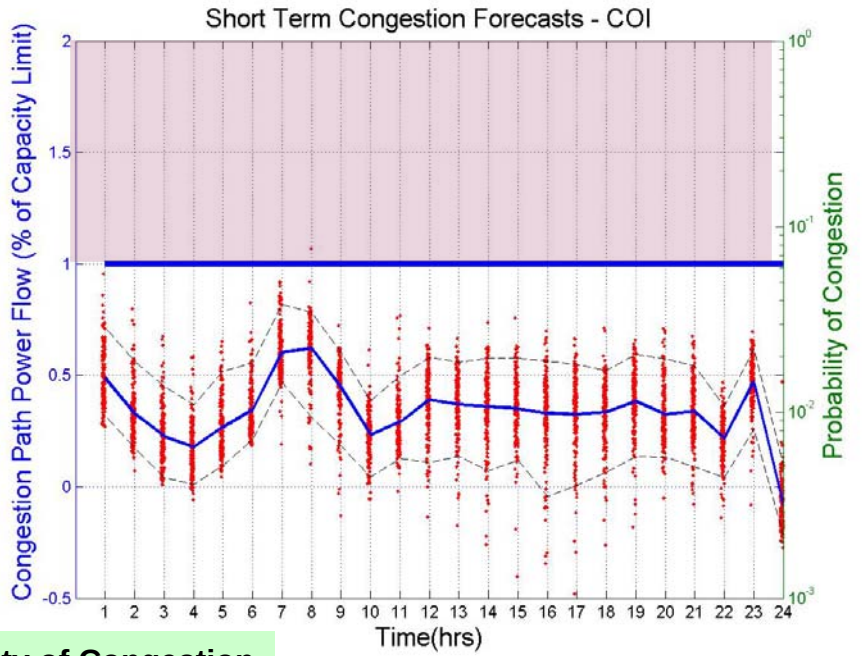
Western Interconnect Congestion Areas, DOE Tasks 1-3 and 4 Online:
http://www.wecc.biz/documents/library/WCATF/Report_to_DOE_050806_Tables1-2-3_and_Maps_ver2.ppt

Graphic Output – Short-Term

With Typical Variation of Wind Generation



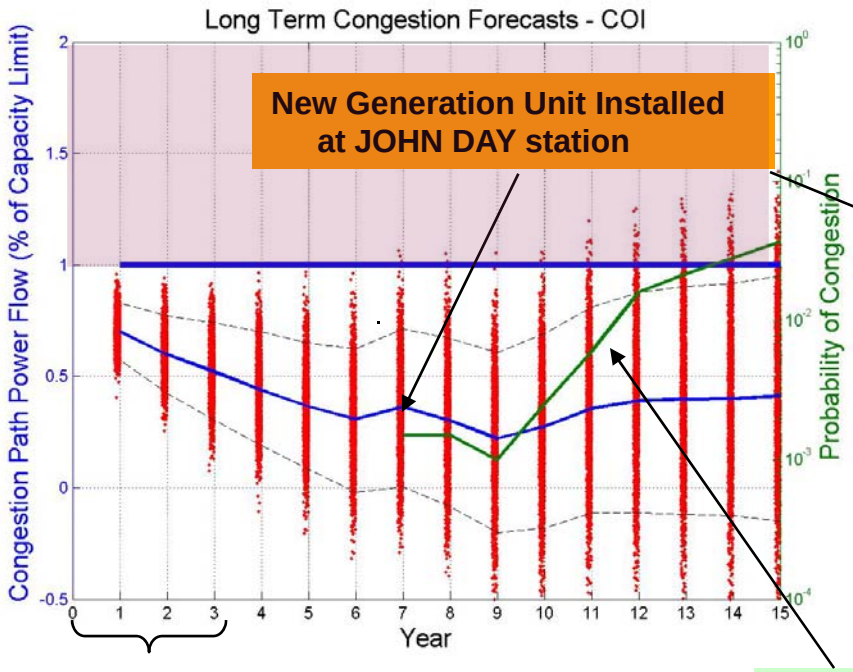
With Assumed Constant Must-run Generation

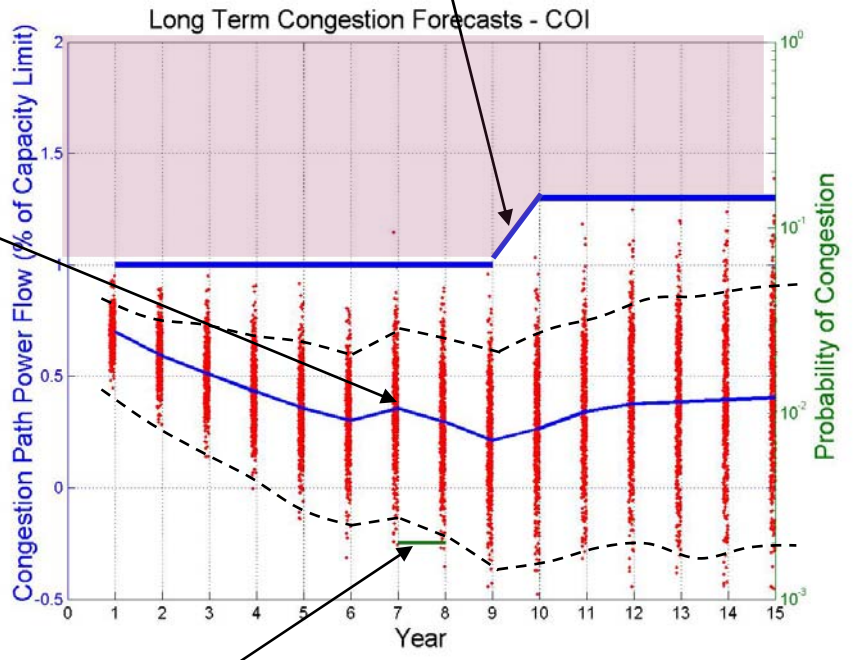


Probability of Congestion

Graphic Output – Long-Term

Hypothetical Upgrade





More and More Wind Power is installed and integrated into the California system

Probability of Congestion

What this Means for California?

With these tools, we can answer these policy questions:

- How much of the uncertainty about congestion comes from customer demand?
- How much reduction in congestion would come from managing load growth and demand side options?
- How much of the uncertainty about congestion comes from generator siting uncertainty, construction delay or retirement?
- How much of the uncertainty comes from renewable resources, especially wind power?
- How much of the uncertainty comes from electric vehicles?

Conclusions

- Importance of both projects
- Benefits to California – Prevent blackouts and power crisis
- Valuable for Integration Study of Wind Power and Electric Vehicles
- Valuable for Holistic Planning of Transmission, Resources and Demands